QUE 94204: AN EH-CHONDRITIC MELT ROCK. M. K. Weisberg[1], M. Prinz[1] and C. E. Nehru[1,2]. 1. Dept. Earth Planet. Sci., Amer. Mus. Nat. Hist., NY, NY 10024; 2. Dept. Geology, Brooklyn College, Bklyn, NY.

INTRODUCTION: The enstatite meteorites are a complex clan of chondrites, achondrites and other melt rocks that comprise the most reduced materials in the solar system. The E chondrites include at least two groups (EH and EL) with unequilibrated and equilibrated types and an anomalous E3 (LEW 87232) which probably represents a third group [1]. The aubrites (AUB) are the major E achondrite group [2]. There are three other apparently unrelated melt rocks, including Shallowater, which has a complex multi-stage history and may represent its own parent body [3], and Ilafegh 009 and Happy Canyon, proposed to be impact melt rocks from E chondrite parent bodies [4-6]. Happy Canyon was also interpreted to be an internally derived melt [7]. Here, we present a petrologic study of QUE 94204 (Q94), a new E meteorite, tentatively described as an E7 [8]. Our purpose is to understand the petrogenesis of Q94 in relation to other E meteorites and their parent bodies, and explore the question of impact vs. internal melting on E chondritic parent bodies.

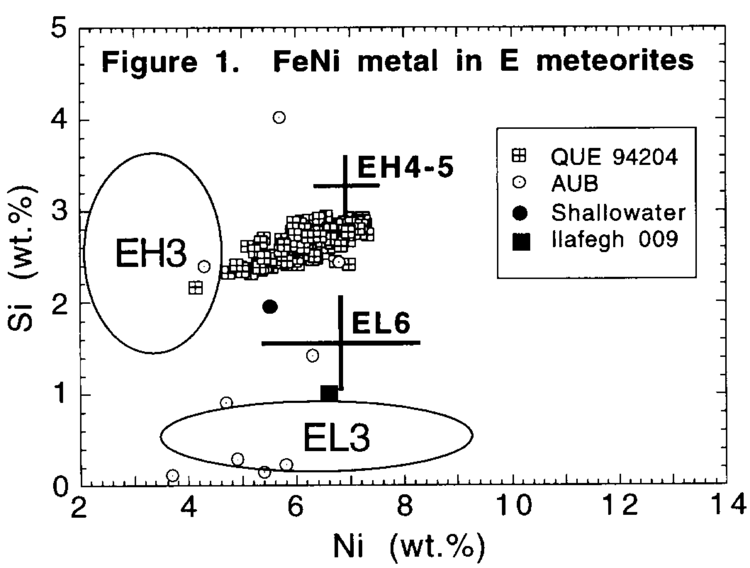
RESULTS: ***Textures and Modes***. Q94 is an unbrecciated coarse-grained rock with an igneous texture. It consists of 73.2 vol.% enstatite (En), with an average grain size of ~1.5mm, and 13.8 plagioclase (Plag), 2.5 silica, 10.5 FeNi (including <1.0 schreibersite and perryite) and 2.5 sulfides (mostly Ti-Cr-bearing troilite and daubreelite, minor-trace oldhamite-CaS, niningerite/alabandite-MgMnS and Millerite-NiS). Modally, it is similar to the E chondrites [1]. Plag is mostly interstitial to, but also occurs as inclusions within, the En. The FeNi is coarse-grained (1-2mm) with irregular outlines and contains small perryites. Schreibersite always occurs as small (~20µm) grains at the peripheries of the FeNi. Some FeNi grains contain spectacular clusters of graphite blades. The sulfides generally occur in spherical to semi-spherical polymineralic assemblages both within and interstitial to the En. Sulfide assemblages which generally contain FeNi and sulfides are within En and are associated with a Si-Al-K-rich glass. Daubreelite is nearly always in exsolution relationship to the troilite. All of the oldhamite in this sample has been terrestrially weathered to a secondary Ca-sulfate mineral. The altered oldhamite occurs in the sulfide assemblages within the En, but also as veins throughout the meteorite. It is not clear whether the occurrence of this mineral as veins is the result of precipitation from solution during terrestrial alteration or if oldhamite veins were present in Q94 prior to alteration. Considering the high melting temperature of oldhamite and the implausibility of producing a pure oldhamite melt on an E meteorite parent body, it is more likely that the veins resulted from terrestrial alteration. Nonetheless, the compositional similarity between oldhamite altered *in situ* (in sulfide assemblages in En) and the veins suggests that this question needs further exploration. Unlike AUB, Shallowater and Happy Canyon, Q94 does not contain forsterite and no diopside was found. Ilafegh 009 is the only other E melt rock without olivine or diopside. ***Mineral Compositions***. The En is fairly homogeneous and pure with most grains having ^{2}0.2 wt.% FeO and 0.2 CaO (Table 1). Some En grains have up to 0.5 FeO; however, Fe values are susceptible to contamination from limonite staining which occurs throughout the rock. En in the AUB and other E melt rocks have ^{3}0.4 CaO [2-6]. The average interstitial Plag composition is $An_{22.5}$, $Or_{2.4}$ and it appears to be more calcic and less potassic than the average Plag within the En ($An_{13.5}$, $Or_{3.9}$), but this may be due to sampling. Plag in the AUB ($An_{1.8-23.8}$, $Or_{1.3-4.6}$) and Shallowater ($An_{7.7}$, $Or_{3.8}$) overlap in composition with, but is generally more albitic than that in Q94 [2,3]. Plag in Ilafegh 009 ($An_{\sim20}$, $Or_{\sim3}$) [4-6] is similar in composition to average Plag in Q94. The Si-Al-K-rich glass inclusions in Q94 are remarkably similar to K-rich inclusions in Ilafegh 009 [4-6]. Most sulfides in Q94 are unlike those in the AUB or any of the E chondrites or melt rocks. Troilite has 1.2 Ti, 0.8 Cr and Mn is close to detection limits at 0.04. Daubreelite is similar to that in Ilafegh 009, with 18.7 Fe, 35.5 Cr, 0.12 Ti and 1.9 Mn. The rare MgMnS present in Q94 is unlike that in any other E meteorite with 18.3 Fe, 12.4 Mg, 22.9 Mn, 0.4 Cr and 44.3 S and indicates a low equilibration temperature (<<600°C) [9]. Millerite with 1.7 Fe, 63.3 Ni and 35.6 S has not been found in AUB or other E melt rocks. Analyses of the altered oldhamite resulted in low totals indicating the possible presence of H_2O. The metal is Si-bearing with an average composition of 91.6 Fe, 6.1 Ni, 0.36 Co and 2.6 Si. The high Si content of the metal is unlike that in most AUB and is most similar to metal in EH chondrites (Fig. 1).

DISCUSSION. The coarse-grained euhedral En with Plag, sulfide and K-rich glass inclusions suggests an igneous origin for Q94. The modal and mineralogical similarity of Q94 to EH chondrites suggests that it is essentially unfractionated and formed by complete melting of an EH-like source material. The En and Plag co-crystallized and the En trapped the earliest formed Plag, as well as K-rich melt. FeNi crystallized last, filling the interstices of the En and thus acquiring irregular shapes. The coarse euhedral texture of the En suggests that Q94 cooled slowly in the interior of a parent body. The unfractionated E chondrite-like bulk compositions of Ilafegh 009 and Happy Canyon led workers to the conclusion that they are impact melt rocks from an E chondrite parent body [4-6]. However, we find no compelling evidence to interpret Q94 as impact-formed. It is highly unlikely that the coarse texture of Q94 could have developed during rapid cooling of an impact melt. More slowly cooled impact melts or melt pools seem less likely. Density-driven metal-silicate fractionation would be expected to occur in any igneous scenario that involves complete melting of the source material, including impact melting. In industrial iron and steel making, separation of a metal from silicate liquid takes place in $<10^3$sec over distances of ~10m [10]. This would create a problem for interpretation of the metal-rich Ilafegh 009 and Happy Canyon as impact melts too. To deal with the problem of metal-silicate fractionation in Happy Canyon, Olsen et al. [7] raised the possibility that melting at depth (>7km), in an EH-like chondritic parent body would result in the congruent melting of En and the acceleration due to gravity would be relatively low. We suggest that this is a possible scenario for Q94. We conclude that Q94 is an internally-derived melt rock from an EH-like parent body. The interpretation of Ilafegh 009 and Happy Canyon as impact melt rocks also needs to be reconsidered.

Table 1. Average (range) compositions (wt.%) of QUE94204 silicates.

	En	Plag	Silica	K-rich Glass
SiO_2	59.0 (59-60.3)	63.4 (60.5-68.0)	95.3	76.4 (76.3-76.4)
Al_2O_3	0.08 (0.04-0.1)	23.0 (18.3-25.0)	2.6	13.4 (13.3-13.6)
FeO	0.21 (0.06-0.5)	0.18 (0.05-0.50)	<0.03	0.15 (0.10-0.18)
MgO	39.7 (38.6-41.1)	<0.03	<0.03	<0.03
CaO	0.20 (0.16-0.26)	4.9 (1.0-7.1)	<0.03	<0.03
Na_2O	<0.03	9.0 (7.8-11.0)	1.0	3.0 (2.6-3.3)
K_2O	NA	0.44 (0.29-0.1.5)	<0.03	7.3 (7.2-7.3)
Total	99.1	100.9	98.9	100.3

TiO_2, Cr_2O_3, MnO <0.03; NA-not analyzed.



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